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that the numbers joined might theoretically come at once. Our theory seems, therefore, to be proved correct as far as it goes, and sufficiently so to justify another inference, viz: that when the longer petal is on the right side, the parts of the flower are arranged in a right handed spiral; and when it is on the left side the spiral is left handed; and, therefore, that in the inflorescence successive flowers on the same branch have spirals in opposite directions.

But why in opposite directions? And why, too, should stamens imitate leaves in the order of their development? Is it a kind of structural memory, or material instinct? The habits of growth impressed by one set of circumstances where they are advantageous, showing themselves where they clearly have not the same advantage, if any at all?

Where shall we stop? But before leaving the case, let us not overlook the fact that in the later explanations, we have been giving reasons of a very different order from those in the earlier. We then thought it sufficient to show the advantage in a particular arrangement, now we are almost satisfied when we see *how* certain forces, more or less familiar, may have produced the facts under consideration. Neither kind of solution is complete. Let us not be deceived by the ambiguity of the word *why*. It should still be asked *how* the structures so admirably adapted to cross-fertilization have been produced, and we may still ask *why* the facts concerning the stamens exist. Whether they are advantageous and serve a purpose in the economy of nature, or whether they are, as it were, rudimentary phenomena, the incidental effects of laws which have been established for some really important purpose. Such questions we have now no time to follow.

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DESTRUCTION OF OBNOXIOUS INSECTS BY MEANS OF FUNGOID GROWTHS.

BY PROF. A. N. PRENTISS.

ENTOMOLOGISTS have been, for a long time, endeavoring to discover some available means for checking the ravages of obnoxious insects, and of late the possibility of employing fungoid growths for this purpose has been receiving considerable attention. The most important paper which has appeared upon the subject is a pamphlet by Dr. H. A. Hagen, of Harvard University, in which he advocates the use of the yeast fungus for the purpose in question.[1]

A proposition of this kind, emanating from so high an authority, is worthy of the most careful consideration.

It seems that the possibility of destroying insects by infesting them with fungi from spores artificially sown, attracted the attention of Dr. Bail, of Prussia, more than a dozen years ago. His experiments, however, were not conducted with reference to the point in question, but for the purpose of establishing the identity of certain forms of fungi which had been regarded as distinct. That Dr. Bail's conclusions do not follow from his experiments; for instance, that the house-fly fungus *(Empusa muscæ)* and the yeast fungus *(Saccharomyces cerevisiæ)* are merely different developments of the same species—is an opinion, I think, that every mycologist who has had experience in the growth of microscopic fungi will endorse. This, however, does not affect Dr. Hagen's main proposition, inasmuch as the identity of the fungus is of small importance so long as it proves fatal to insects and its application is practicable. Propositions of a similar nature to that of Dr. Hagen's have been made by other scientists, notably by M. Pasteur some years since, whose investigations upon the silkworm disease led him to suggest to the French Commission du Phylloxera, the possibility of destroying the insect which had committed such fearful ravages upon the grape-growing industry of France, by its inoculation with some microscopic fungus.

In this country, as long ago as 1874, the same idea was suggested by Dr. John L. LeConte.[2] He recommends that a careful study of the epidemic diseases of insects be made, especially those of a fungoid nature, hoping thereby that some sweeping remedy may be found by which man can rid himself of insect enemies.

Charles H. Peck, State botanist of New York, advanced the same idea in 1876, only, however, applying it to the destruction of obnoxious plants. He says,[3] "On the other hand, those fungi that infest noxious weeds and hinder their dissemination and multiplication must be regarded as the friends and allies of man. Thus, the thistle rust, *Trichobasis suaveolens*, an early stage of *Puccinia compositarum*, sometimes attacks the Canada thistle with great virulence, and so impairs its vigor as to prevent the development of the seeds, thereby checking the propagation and spread of this pestilent plant. So, also, the troublesome bur-grass, *Cenchrus tribuloides*, is sometimes infested by a smut fungus, *Ustilago syntherismæ*, which not only prevents the development of the seeds of the grass but also the annoying bur-like involucres. It may yet be found practicable to keep down this grass by the artificial dissemination of the spores of its parasitic fungus."

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[1] "Destruction of Obnoxious Insects, Phylloxera, Potato Beetle, Cotton-worm, Colorado Grasshopper and Greenhouse pests, by application of the Yeast Fungus." Cambridge, 1879.

[2] "Proceedings of the American Association for the Advancement of Science," 1874, p. 22.

[3] Twenty-ninth Annual Report on the State Museum of Natural History (1876), p. 30.

Among the facts pointing to a favorable issue of the proposed remedy against obnoxious insects, is the well-known fact that many insects living under wholly natural conditions are annually destroyed by fungi. Cook states that about twenty-five species of the genus Torrubia are known to be parasitic on insects.[1]

Mr. Peck, in his Annual Report on the N. Y. Museum of Nat. Hist. for 1878, says, that "the seventeen-year locust, *Cicada septendecim*, which made its appearance in the Hudson River valley early in the summer, was affected by a fungus. The first specimen of this kind that I saw was taken in New Jersey and sent to me by Rev. R. B. Post. Examination revealed the fact that the Cicadas or 'seventeen-year locusts' in this vicinity were also affected by it. The fungus develops itself in the abdomen of the insect, and consists almost wholly of a mass of pale-yellowish or clay-colored spores, which to the naked eye has the appearance of a lump of clay. The insects attacked by it become sluggish and averse to flight, so that they can easily be taken by hand. After a time some of the posterior rings of the abdomen fall away, revealing the fungus within. Strange as it may seem, the insect may, and sometimes does, live for a time even in this condition. Though it is not killed at once, it is manifestly incapacitated for propagation, and, therefore, the fungus may be regarded as a beneficial one. In Columbia county the disease prevailed to a considerable extent. Along the line of the railroad, between Catskill and Livingston stations, many dead Cicadas were found, not a few of which were filled by the fungoid mass."

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[1] "Fungi, their Nature and Uses," p. 218.

Mr. Peck again, in the same report, says, that "While in the Adirondack region, numerous clumps of alders were noticed that had their leaves nearly skeletonized by the larvæ of some unknown insect. The larvæ were nearly black in color and scarcely half an inch long. They were seen in countless numbers feeding upon the leaves and threatening by their numbers, even if but half of them should come to maturity, in another year to completely defoliate the alders of that region. Upon looking under the affected bushes for the pupæ of the insect, in order, if possible, to have the means of obtaining the species, what was my astonishment to find the ground thickly flecked with little white floccose masses of mold, and that each one of these tufts of mold was the downy fungoid shroud of a dead larva from the alders. Not a single living pupa could be found, but there were hundreds of dead and moldy larvæ, killed without doubt by the fungus, which is nature's antidote to an over production of the insect and nature's agency for protecting the alders from utter destruction."

The "pébrine," a disease which appeared in South France nearly thirty years ago and attacked the silk-worms with much virulence, is also a case in point. A popular account is given of this epizoötic in Huxley's Lay Sermons.[1]

This disease appeared in the rearing houses in great violence in 1854, although it had been occasionally seen previous to that date. The name "pébrine" was given to it because of the dark spots which appeared on the bodies of the infested larvæ.

The malady spread from year to year, until in 1858 the amount of silk produced was diminished to one-third of that which had been made previous to 1853. In brief, a microscopic fungus, preying upon the silk-worm and causing its destruction by thousands, prostrated the industries of the city of Lyons, and plunged its working class into idleness and want. What the total loss was, could not be determined, as all classes of industry suffered, but the direct loss was estimated at $250,000,000.

The fact that the insects mentioned by Dr. Hagen exist in great numbers, is most favorable to the rapid spread of any disease that may appear among them, and the remedy proposed, should it work at all, would probably prove powerful, rapid and insidious. The spread of the potato rot, *Peronospora infestans*, over the whole of the British Isles within two years after its introduction, is an example of how rapidly and thoroughly spores may permeate any region when all the conditions are favorable to their growth.

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[1] Lay Sermons, pp. 373-375.

In examining the question as proposed by Dr. Hagen, many facts must be taken into account before deciding upon the probable results. It must be remembered that the air is at all times charged with the spores of fungi. Dr. Cunningham found that "spores and other vegetable cells are constantly present in atmospheric dust, and usually occur in considerable numbers; the majority of them are living and capable of growth and development."[1]

Dr. S. M. Babcock, who is determining the chemical changes of cheese during the curing process, finds it impossible to avoid mold in the curd except by heat and anæsthetics (ether and chloroform). He states that the spores *seem* to be in the very milk used in the experiments.

In the Botanical Laboratory, where molds and yeast are cultivated at certain times for experimentation, the air soon becomes charged with spores.

Growing in the same laboratory and rooms directly connected with it, are plants which require constant care lest they be overrun with their several insect pests. No disease appears to have attacked these insects. It may be said that they do not feed upon the yeast, and for this reason escape. It is not necessary that the spores be eaten by the insect in the case of the fly fungus *(Empusa muscæ)*. Huxley says:[2] "It has been ascertained that when one of the spores falls on the body of a fly, it begins to germinate and sends out a process which bores its way through the fly's skin; this having reached the interior cavity of the body, gives off the minute floating corpuscles which are the earliest stages of Empusa. The disease is 'contagious,' because a healthy fly coming in contact with a diseased one from which the spore-bearing filaments protrude, is pretty sure to carry off a spore or two. It is 'infectious,' because the spores become scattered about all sorts of matter in the neighborhood of the slain flies."

In this connection it should be noted that while the insects which infest more or less the plants growing in the laboratory have not been affected in any way by the fungi or their spores, the plants themselves, in some instances, have been seriously injured. On one occasion, recently, some experiments which had been commenced with much care upon *Drosera rotundifolia*, were brought to a sudden end by a mold which completely overrun and destroyed the plant. That the air of the laboratory should become abundantly charged with spores, would, of course, be expected from the large number of experiments in the growth and propagation of microscopic fungi which at times are being conducted by the members of the classes in mycology. Indeed after a time the spores become so abundant that all apparatus has to be thoroughly cleansed and fumigation by sulphur resorted to in order that the experiments with the fungi themselves should not be defeated.

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[1] "Microscopical Examinations of Air," from the "Ninth Annual Report of the Sanitary Commissioner." Calcutta, 1872.

[2] "Lay Sermons, Addresses and Reviews," p. 372.

The abundance of these spores of many kinds, including those of the house-fly fungus, emphasizes the fact that aphides and other plant insects, seem to thrive in the midst of these spores without any diminution of their vigor or power of reproduction.

Although our whole experience in the cultivation of fungi, as might be inferred from the statements already made, as also nearly all observations made upon fungoid growths in general, indicate that the yeast fungus offers little promise of success as a remedy against obnoxious insects, nevertheless the matter has been deemed of sufficient importance to warrant a considerable amount of labor in the way of experimentation for the purpose of arriving, if possible, at some definite facts bearing directly upon the subject. A brief account of the methods and results of this undertaking is here given. All of the experiments here described were made on plants growing in pots in the Botanical Laboratory, or in the adjoining rooms, or in a large conservatory window, where the conditions of light, heat and moisture were favorable to the healthful growth of the plants experimented upon.

In conducting the experiments I have been greatly aided by Instructor W. A. Henry, of the Botanical Department, who has also rendered much assistance in collating information relating to the whole subject.

Experiment No. 1.—A strong plant of strawberry geranium (*Saxifraga sarmentosa*) has been allowed to become infested with green aphides. They are mostly confined to the flower peduncles and young tips of the runners.

May 13.—The plant is thoroughly sprinkled with dilute yeast by means of a flat paint brush so that all parts, especially those covered with aphides, are fairly wet. The yeast used is fresh domestic yeast, diluted with two-thirds water. Torulæ are active, as is shown from the fermentation in progress. After being sprinkled the plant is placed by itself on a table and covered by a large funnel-shaped hood, made of thin white paper, slightly open at the bottom to admit air. A cup of actively fermenting yeast is placed at the side of the plant under the hood, so that any germs which may possibly escape from the yeast will be confined to the air immediately surrounding the plant. Some of the older leaves are infested with a number of scale insects.

May 15.—No dead aphides are to be found. Some cast-off skins from molting are seen.

May 18.—Peduncles and tips of runners are loaded with plump aphides. Many cast-off skins. No dead insects are found. The scale insects larger and apparently more numerous.

May 20.—All young parts completely covered with aphides.

June 3.—The plant is obviously injured from attack of aphides and scale insect. Some of the leaves are dead. The plant is out of flower and the peduncles are more or less withered. On these peduncles are a number of dead aphides. These might have starved for want of food, owing to the drying up of the juices of the peduncles. A number of dead aphides are examined under the microscope in a variety of ways, but in no case is there any appearance of Torulæ or other fungoid growths. Numerous live aphides are found on the younger parts of the plant.

Experiment No. 2—May 13.—A small geranium plant (*Pelargonium angulosum* var.), infested with a considerable number of aphides, is sprinkled with domestic yeast (the same as in No. 1), and placed in a window in its ordinary position among other plants not infested.

May 15.—Aphides more scattered but apparently not less in number.

May 18.—Aphides plainly more numerous. Numbers of cast-off skins from molting. Some leaves of geranium with dark-brown spots obviously caused by drops of yeast; other plants of the same kind not treated with yeast show no spots.

June 3.—Aphides numerous and healthy. Quantities of cast-off skins. No dead aphides to be found. Foliage obviously injured by the yeast. Plant plainly enfeebled by the aphides.

[*To be continued.*]